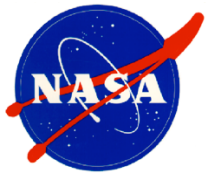

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Coordinated Science Campaign Planning for Earth Observing Missions

Earth Science Technology Conference 2004

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Motivation

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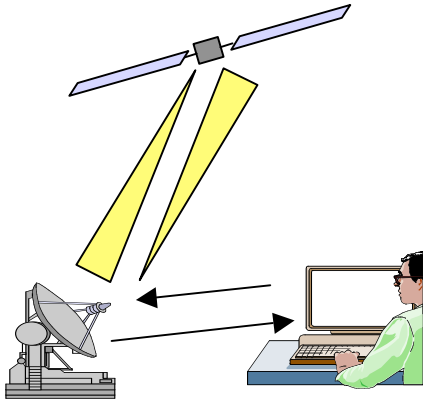
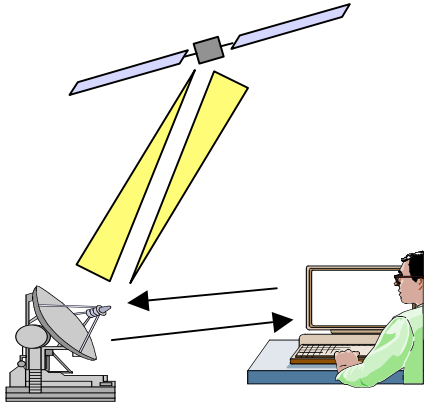
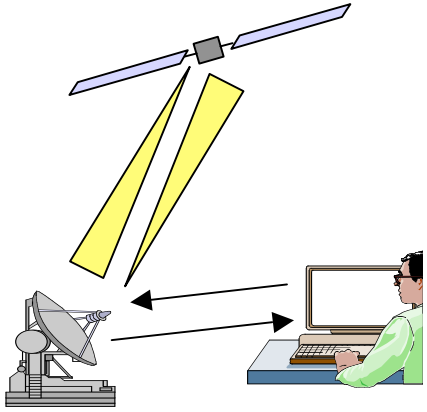
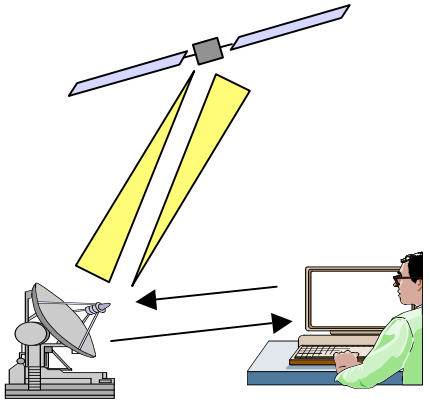


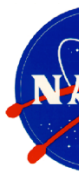
Problem: Lack of coordination among mission operations for Earth science planning.



Results: Sub-optimal utilization of sensors, difficulty planning for coordinated observations.







Solution: Coordinated Science Planning System

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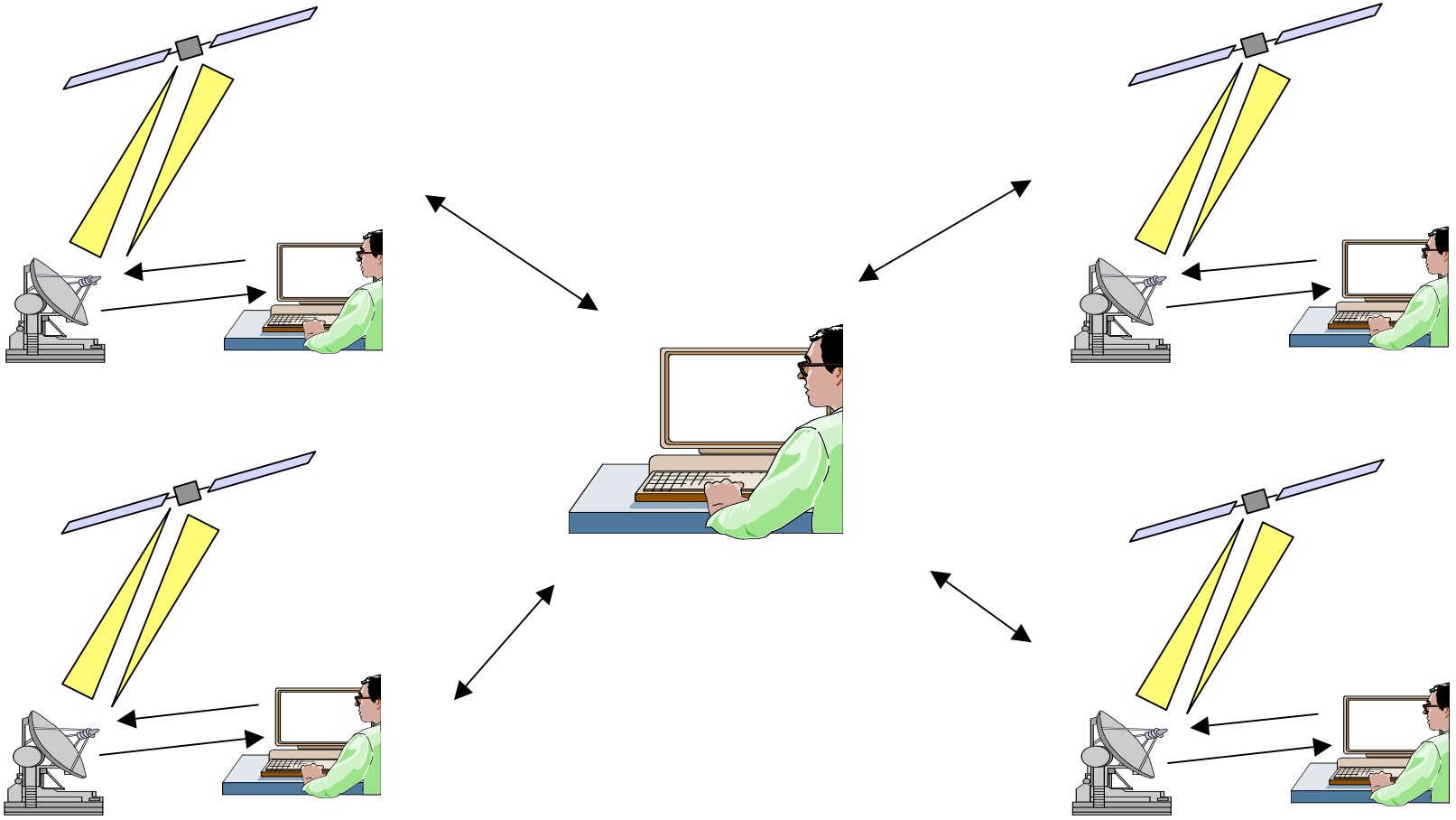

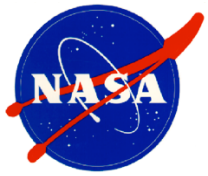

Current practice: image archive access tools

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Government

NASA EOSDIS Data Gateway

USGS Earth Explorer

USGS Global Visualization Viewer

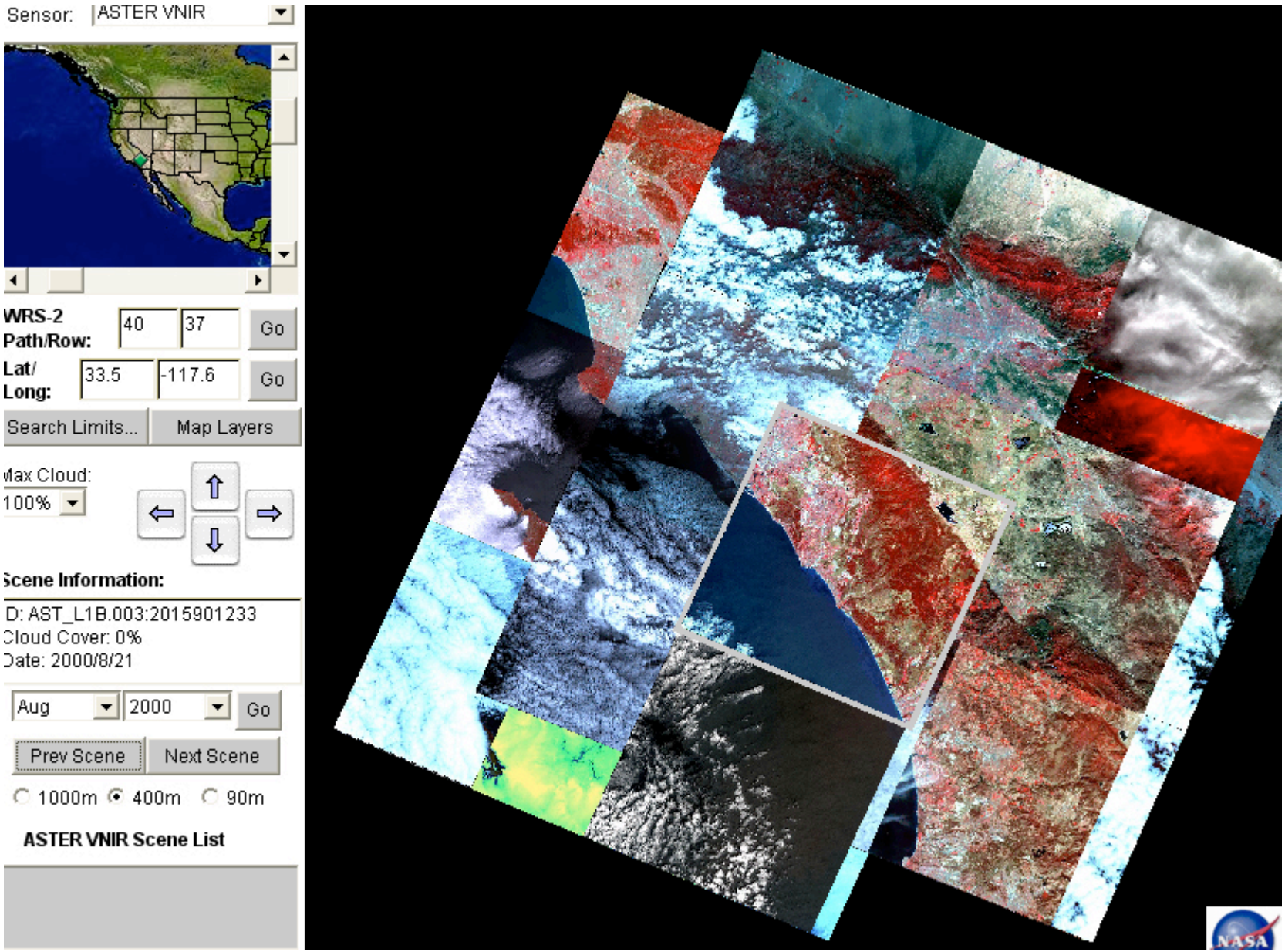
Commercial

Space Imaging (IKONOS)

Digital Globe (QuickBird)

Terraserver

Graphical Data Archive Search Tools



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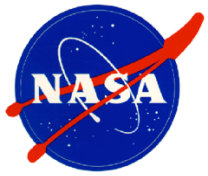

Objective

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- Develop an automated system that provides a suite of services for **campaign planning.**
  - Provides a single information portal into mission science planning operations.
  - Integrated tool for constructing and executing a set of requests to Earth observing missions.
- Proviso: Each mission maintains authority over its own observation schedules.

Why a Coordinated Science Planner?

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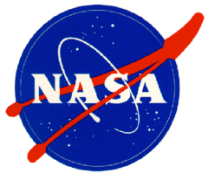
Earth scientists decide how best to use all available resources to accomplish campaign goals

=> Improved science

=> Improved scientist productivity

Users acquire a degree of visibility and access to the schedules and resources of a collection of missions.

=> More efficient coordinated resource planning



Earth Science Campaign

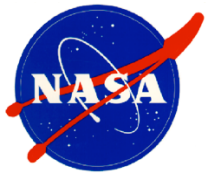
A coordinated effort to collect satellite measurements towards a science goal

- A set of measurements

Each measurement consists of

- A sensor capability
- A location on the Earth
- A desired time window
- Other constraints

Exogenous events (fires, hurricanes, etc.)



Example campaign

Goal: Validate an emissions model predicting the aerosols released by wildfires.

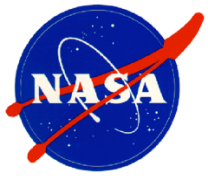
Measurements required or desired:

- Vegetation type/biomass (required)
- Fuel moisture content (desired)
- Fire temperature (required)
- Aerosol concentration (required)
- Burned area (required)

Location: San Diego County

Requested Times:

- Vegetation type/biomass --> priori to fire (summer)
- Fuel moisture content --> just prior to fire
- Fire temperature --> coincident to fire
- Aerosol concentration --> coincident to fire
- Burned area --> after fire



Example Campaign

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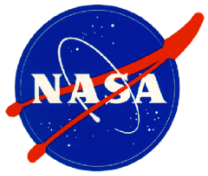
Available Sensors

- ETM+ or TM -- vegetation type.
- Hyperion (EO-1) -- moisture content, just preceding the fire
- MODIS (Aqua) -- aerosol concentration, coincident to fire, pm
- MODIS (Terra) -- aerosol concentration, coincident to fire, am
- MOPITT (Terra) -- aerosol concentration, coincident to fire, am
- ASTER (Terra) or TM (Landsat) -- fine spatial resolution burned area, post-fire
- MODIS (Terra) -- coarse spatial resolution burned area, post-fire, am
- MODIS (Aqua) -- coarse spatial resolution burned area, post-fire, pm



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Campaign constraints

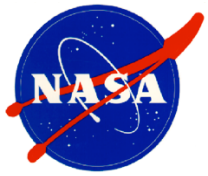
Small set of observations with constraints on time, location, sensor capability

Interactions with exogenous events (e.g. fires)

--> Uncertainty in execution

Potentially many ways of satisfying a campaign

--> Flexibility in planning



System Requirements

Distributed: collaborative effort with missions

Mixed-initiative: user formulates campaign with automated assistance

Combined planning and execution: system enables observation requests to be submitted to missions

Distributed Earth Science Observation Planning and Scheduling (DESOPS)

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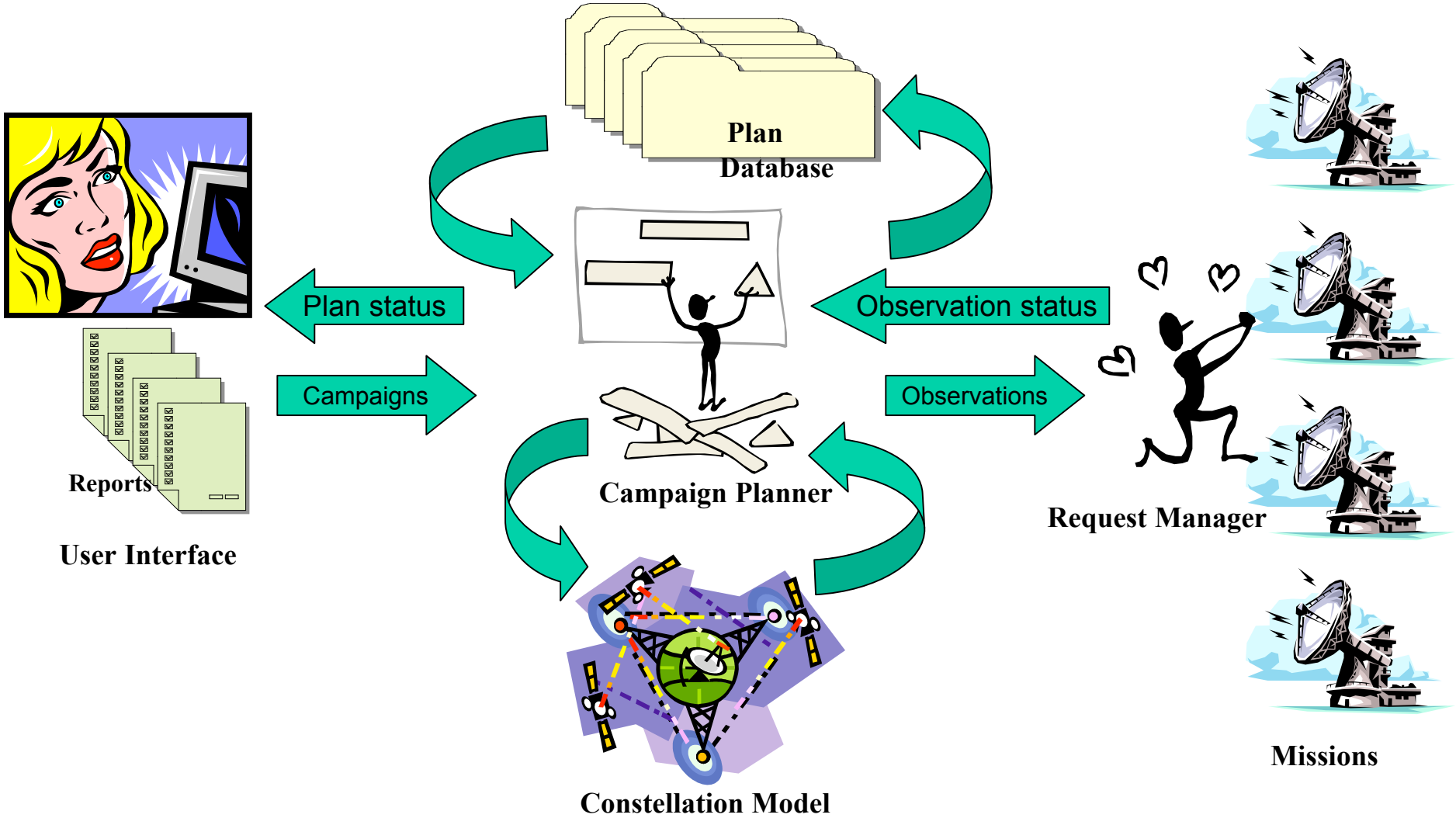

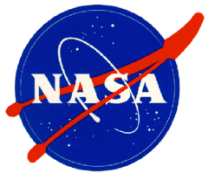

How will it work?

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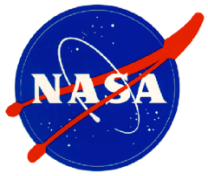
A user specifies a campaign, including the observations and associated constraints.

A campaign is represented as a (flexible) plan.

- A planner uses a model of the system of sensors to support the construction of plans.

Observation requests, allocating instruments, locations, and times, are automatically submitted to mission schedulers as required by the plan.

Missions may reject a request, triggering replanning actions, potentially spawning new requests.



System Components

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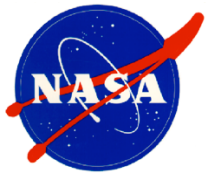
- Plan database
  - Stores campaign constraints, generated plan, execution status.
- Constellation model
  - Describes the resources available to build campaigns.
- Request manager
  - Enables plan execution
  - Communication infrastructure with mission planners
- User interface
  - Displays geographic, network and text-based information to the user and allows interactive input



Flexible temporal plan

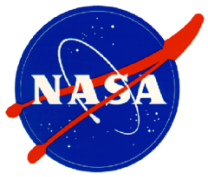
An temporally ordered set of events.

Start times and durations between events are represented as intervals of time.

Way of depicting range of acceptable times.

For example, “X can occur between 1 and 60 days after Y”.

This representation of a plan has advantages for use in systems that combine planning with execution.



Flexible Plan for Fire Campaign

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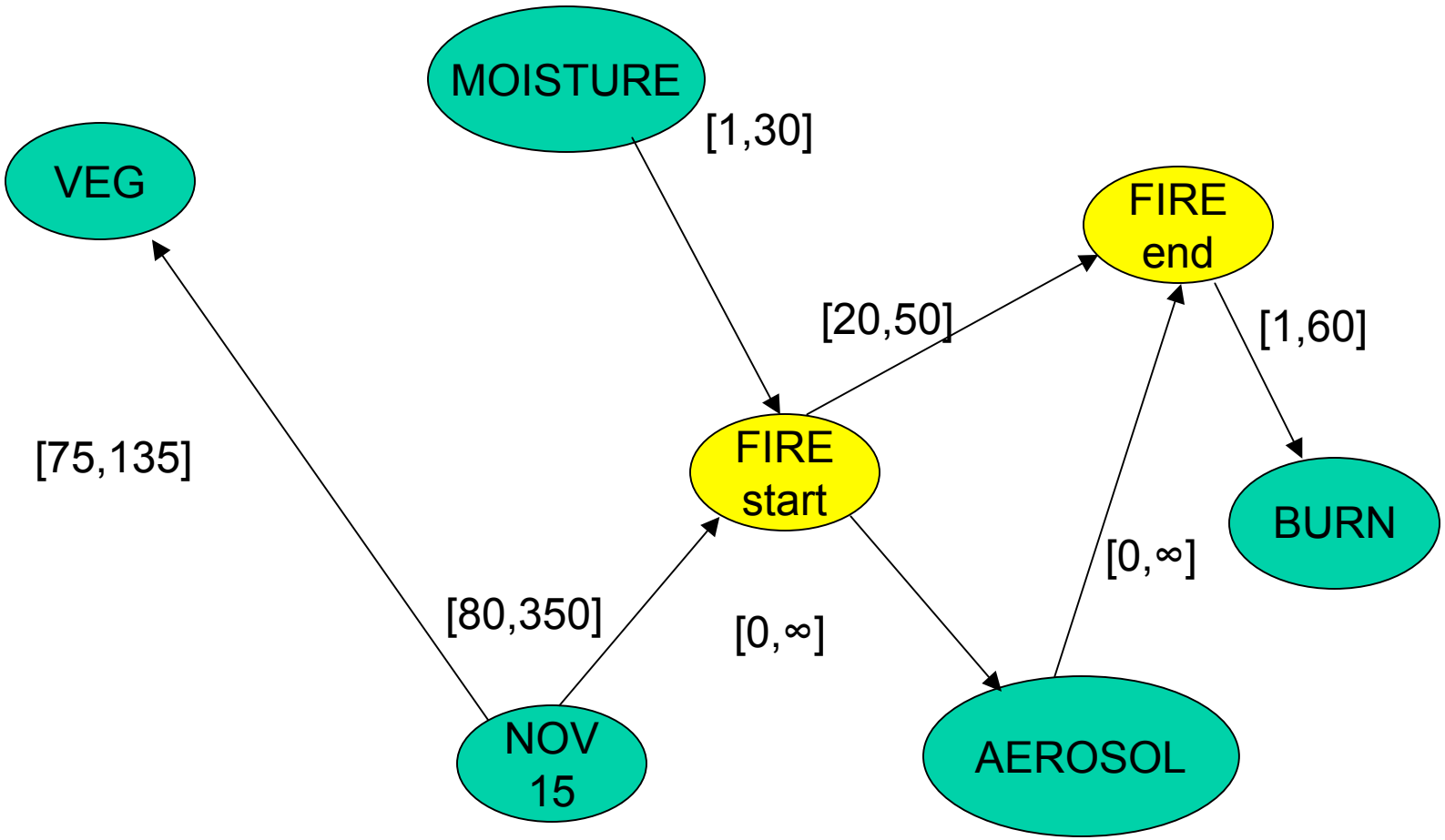

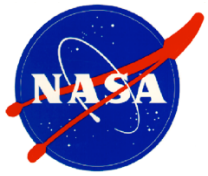

Technical Challenges

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Complex constraints

- Preferences and utility
- Repeat observations
- Required vs. desired observations

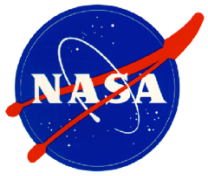
Execution uncertainty and dynamic replanning

- Coordination with missions

Exogenous events

- Planning under uncertainty

Optimization planning considering costs and utility



Related Work

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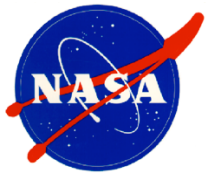
- Earth Science mission planning and scheduling systems
  - Landsat 7 Spot 5, Aster
- ASE EO-1 planning
  - Coordinated planning through on-board analysis
- MAPGEN for Mars Exploration Rover Science Planning
- PlanSat by Soligence



Project Status

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- Prototype component planning technology has been developed
  - Generates flexible plans and allows specification of temporal preferences.
- Database infrastructure based on MOPPS/AMPS system
  - Constellation model and plan database designed and in development.
- User Interface under development
  - Look and feel will resemble interfaces to archive data retrieval systems.